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LIQUID CRYSTAL DISPLAY DEVICE, MANUFACTURING METHOD THEREFOR AND MANUFACTURING DEVICE FOR LIQUID CRYSTAL DISPLAY DEVICE

[Abstract]

PROBLEM TO BE SOLVED: To shorten the time required for pushing out a liquid crystal for obtaining the optimum gap of a panel which is already filled with the liquid crystal, in a vacuum injecting method of a liquid crystal display element.

SOLUTION: In a liquid crystal display device wherein the liquid crystal 3 is injected into a vacant cell of the liquid crystal display element 1 having substrates 2a and 2b opposed to each other, a gap controlling member 6 for forming the gap between the substrates 2a and 2b opposed to each other of the liquid crystal display element 1 has the area density of ≥ 0.08% and the compression elastic

modulus of ≥ 150×9.80665×104 Pa (150 kgf/cm2). In manufacturing the liquid crystal display device, the time required for pushing out the liquid crystal 3 before the optimum gap is obtained after the liquid crystal 3 is injected into the vacant cell can be shortened. In particular, the low-cost liquid crystal panel can be provided by shortening lead time, the excellent quality in gap uniformity in the panel surface is obtained and the in-panel plane shaking due to the vibration of finished panel is reduced.

[Claims]

[Claim 1]

A liquid crystal display apparatus in which liquid crystal is injected into empty cells of a liquid crystal display device having opposite substrates,

wherein an area density of a gap control member that forms a gap of the opposite substrates of the liquid crystal display device is 0.08 % or higher, and a compression elastic coefficient thereof is $150\times9.80665\times10^4$Pa(150kgf/$cm^2$) or higher.

[Claim 2]

The liquid crystal display apparatus according to Claim 1, wherein the gap control member forming the gap of the opposite substrates of the liquid crystal display device is a projection formed on a substrate.

[Claim 3]

The liquid crystal display apparatus according to Claim 1, wherein the gap control member forming the gap of the opposite substrates of the liquid crystal display device is a ball having a spherical shape.

[Claim 4]

A method of manufacturing a liquid crystal display apparatus, comprising the steps of:

in a state where an area density of a gap control member that forms a gap of the opposite substrates of a liquid crystal display device is 0.08 % or higher, and a compression elastic coefficient thereof is $150\times9.80665\times10^4$Pa(150kgf/$cm^2$) or higher, adhering the substrates to form an empty cell of the liquid crystal display device; and

injecting liquid crystals from an inlet port of the empty cell into a vacuum tank, and compressing the liquid crystals from the inlet port by applying pressure of $2\times9.80665\times10^4$Pa($2kgf/cm^2$) or less to a given gap.

[Claim 5]

The method according to Claim 4, wherein the gap control member forming the gap of the opposite substrates of the liquid crystal display device is a projection formed on a substrate.

[Claim 6]

The method according to Claim 4, wherein the gap control member forming the gap of the opposite substrates of the liquid crystal display device is a ball having a spherical shape.

[Claim 7]

A manufacturing apparatus of a liquid crystal display apparatus that implements a manufacturing method according to any one of Claims 4 to 6.

[Title of the invention]

LIQUID CRYSTAL DISPLAY DEVICE, MANUFACTURING METHOD THEREFOR AND MANUFACTURING DEVICE FOR LIQUID CRYSTAL DISPLAY DEVICE

[Detailed Description of the Invention]

[0001]

[Field of the invention]

The present invention relates to a liquid crystal display apparatus and manufacturing method thereof, and a manufacturing apparatus of a liquid crystal display apparatus, wherein OA equipment such as a personal computer, a word processor and a monitor display, portable information communication devices and the like.

[0002]

[Description of the Prior Art]

In a method of manufacturing a liquid crystal display device, a method of filling a liquid crystal cell with liquid crystal includes an injection method and a dropping method. The injection method is generally used for mass production, and includes filling liquid crystal from the inlet port of an empty cell by way of a pressure difference and a capillary phenomenon under vacuum.

[0003]

FIG. 6 shows a process flowchart of a liquid crystal display device manufactured by a conventional injection method. A liquid crystal display device 1 has a cross-sectional structure shown in FIG. 7. Liquid crystal 3 is intervened in a gap between two sheets of substrates 2a and 2b having display electrodes therein. Spacers 4 are dispersed to form a predetermined gap. A polarization plate

or other optical films are disposed at both sides of the two sheets of the substrates 2a and 2b. The polarization plate can be one, two or may not be used according to the principle method. The formed liquid crystal display device 1 is adapted to display an image by irradiating light from an opposite side of the display surface to a three-wavelength type cold cathode tube in the case of a transmission type. Further, in the case of a reflection type, a reflection plate is disposed at an opposite side of the display surface and external light is used. A voltage is applied to the liquid crystal display device 1, which serves as a display.

[0004]

A conventional manufacturing flowchart of the liquid crystal display device 1 shown in FIG. 6 will be below described. In the injection method, the substrates 2a and 2b are cleaned. An orientation film of a liquid phase is coated on the substrates 2a and 2b by means of offset print, etc., and then undergoes a first sintering process and a second sintering process. Then, an orientation process such as rubbing is performed on the orientation film. Generally, after rubbing, water cleaning is performed in order to remove alien substance or dirty on the surface of the orientation film. Thereafter, a sealant 5 is coated on one of the substrates 2a by means of a patterning apparatus or screen printing, thus forming a seal 5. The seal pattern has at least one to five inlet ports. The inlet port is generally referred to as an inlet port. Liquid crystal 3 is injected from the inlet port. Further, in order to form a gap in the other of the substrates 2b, spacers 4 having a predetermined size are sprayed, and both the substrates 2a and 2b are adhered under atmosphere. In this case, the spacers 4 are generally made of organic-based resin such as benzoguanamine, or inorganic-based resin such as SiO_2.

[0005]

However, in order to control the gap of the liquid crystal display device 1, the two sheets of the substrates 2a and 2b are pressurized by means of air press, etc. If an optimal gap is output, the sealant 5 is hardened. At this time, the sealant 5 of a thermosetting type is usually used. Thereafter, portions other than the substrate display region are cut. This state is called an empty cell. The empty cell becomes greater than a proper gap if it is left in the atmospheric pressure.

[0006]

In the injection method, an aperture of an inlet port of the empty cell formed thus and the liquid crystal 3 are pooled and then kept in a vacuum tank. The entire tank is open to the atmosphere from 0.2×133.332 to 0.7×133.332Pa (or 0.2 to 0.7 Torr), filling the empty cell with the liquid crystal 3. The liquid crystal quantity filled in the cell of this state exceeds an optimal quantity and the gap is also greater than a proper value.

[0007]

Further, the inlet port is closed using resin, etc. The liquid crystal 3 attached to the liquid crystal display device 1 is cleaned. A re-orientation process is performed on the liquid crystal 3 by annealing the entire liquid crystal display device 1.

[0008]

[Problem(s) to be Solved by the Invention]

In the manufacturing method of the conventional liquid crystal display device, the time from when an empty cell is filled with liquid crystal until when the liquid crystal is compressed up to a proper gap is significant. The inlet port is then sealed. If a panel size is obtained, compressing the filled liquid crystal needs time that much. Generally, the liquid crystal panel in which the liquid crystal is filled has a gap at the center is swollen higher than the circumference. This is due to elastic deformation power of the spacers that are sprayed in order to form the gap of the liquid crystal panel, and a process of hardening the seal. In order to remove extra liquid crystal, the liquid crystal pane l in which the liquid crystal is filled is pressurized up and down, and the liquid crystal is slowly compressed. The reason why the liquid crystal pane l is slowly pressed is that if the pressure is not uniform, the gap can collapse, or the liquid crystal is excessively compressed. If the liquid crystal is excessively compressed, bubbles can enter the liquid crystal or lots of sealing resin enters the liquid crystal. Actually, in order to compress the liquid crystal, several tens of time is taken in a middle-size panel, and one hour is taken in a large-size panel.

[0009]

This process tact is very difficult to lower the cost. In order to increase the production amount, the number of equipment inevitably increases. This is a significant problem in commercializing a liquid crystal panel.

[0010]

Accordingly, an object of the present invention is to provide a liquid crystal display apparatus and manufacturing method thereof, and a manufacturing apparatus of a liquid crystal display apparatus, wherein a compression time taken

to make a panel filled with liquid crystal become an optical gap can be shortened in a vacuum injection method of the liquid crystal display device.

[0011]

[Means for Solving the Problem]

In order to accomplish the above, a liquid crystal display apparatus according to Claim 1 of the present invention is a liquid crystal display apparatus in which liquid crystal is injected into empty cells of a liquid crystal display device having opposite substrates in Claim 1. In this case, the area density of a gap control member that forms a gap of the opposite substrates of the liquid crystal display device is 0.08 % or higher, and the compression elastic coefficient thereof is $150\times9.80665\times10^{4}$Pa($150kgf/cm^{2}$) or higher.

[0012]

As such, the area density of a gap control member that forms a gap of the opposite substrates of the liquid crystal display device is 0.08 % or higher, and the compression elastic coefficient thereof is $150\times9.80665\times10^{4}$Pa($150kgf/cm^{2}$) or higher. Accordingly, upon manufacturing of the liquid crystal display apparatus, the time taken to compress the liquid crystal from when an empty cell is filled the liquid crystal until when a proper gap is compressed can be shortened. More particularly, as lead time shortens, not only a low-cost liquid crystal panel cane be provided, but also the gap uniformity within the panel surface is excellent in terms of the quality. Further, vibration within the panel surface due to vibration of a complete panel can be improved.

[0013]

In a liquid crystal display apparatus according to Claim 2, the gap control member forming the gap of the opposite substrates of the liquid crystal display

device is a projection formed on a substrate in Claim 1. As such, since the gap control member forming the gap of the opposite substrates of the liquid crystal display device is a projection formed on a substrate, it can be previously provided in a predetermined location of the substrate upon fabrication.

[0014]

In a liquid crystal display apparatus according to Claim 3, the gap control member forming the gap of the opposite substrates of the liquid crystal display device is a ball having a spherical shape in Claim 1. As such, since the gap control member forming the gap of the opposite substrates of the liquid crystal display device is a ball having a spherical shape, it can be uniformly sprayed on the substrate upon fabrication.

[0015]

A manufacturing method of a liquid crystal display apparatus according to Claim 4 includes the steps of, in a state where the area density of a gap control member that forms a gap of the opposite substrates of a liquid crystal display device is 0.08 % or higher, and the compression elastic coefficient thereof is $150\times9.80665\times10^4$Pa(150kgf/cm^2) or higher, adhering the substrates to form an empty cell of the liquid crystal display device, and injecting liquid crystal from an inlet port of the empty cell into a vacuum tank, and compressing the liquid crystal from the inlet port by applying pressure of $2\times9.80665\times10^4$Pa(2kgf/cm^2) or less to a given gap.

[0016]

As such, in a state where the area density of a gap control member that forms a gap of the opposite substrates of a liquid crystal display device is 0.08 % or higher, and the compression elastic coefficient thereof is

$150\times9.80665\times10^4$Pa(150kgf/cm^2) or higher, the substrates are adhered to form an empty cell of the liquid crystal display device, and injecting liquid crystal from an inlet port of the empty cell into a vacuum tank, and the liquid crystal is compressed from the inlet port by applying pressure of $2\times9.80665\times10^4$Pa(2kgf/cm^2) or less to a given gap. The time from when an empty cell is filled with liquid crystal until when the liquid crystal is compressed up to a proper gap can be shortened. Thereby, process tact for filling the liquid crystal of the liquid crystal display device can be significantly shortened. Further, a liquid crystal display apparatus with a high yield can be fabricated simply and by means of a conventional manufacturing method. More particularly, a low-cost the liquid crystal panel can be provided through reduction in lead time. Meanwhile, in terms of the quality, the gap uniformity within the panel surface is good, and vibration within the panel surface due to vibration of a complete panel is improved.

[0017]

In a manufacturing method of the liquid crystal display apparatus according to Claim 5, the gap control member forming the gap of the opposite substrates of the liquid crystal display device is a projection formed on a substrate in Claim 4. As such, since the gap control member forming the gap of the opposite substrates of the liquid crystal display device is a projection formed on a substrate, it can be provided at a predetermined location of the substrate.

[0018]

In a manufacturing method of the liquid crystal display apparatus according to Claim 6, the gap control member forming the gap of the opposite substrates of the liquid crystal display device is a ball having a spherical shape in Claim 4. As such, since the gap control member forming the gap of the opposite substrates of

the liquid crystal display device is a ball having a spherical shape, it can be evenly sprayed on the substrate.

[0019]

In a manufacturing apparatus of a liquid crystal display apparatus according to Claim 7, a manufacturing apparatus of a liquid crystal display apparatus that implements a manufacturing method according to any one of Claims 4 to 6. As such, since the manufacturing method according to any one of Claims 4 to 6 is implemented, the same effects can be obtained.

[0020]

[Embodiment of the Invention]

An embodiment of the present invention will now be described with reference to FIGs. 1 to 5. FIG. 1 is a cross-sectional view of a liquid crystal display apparatus according to an embodiment of the invention.

[0021]

Referring to FIG. 1, a liquid crystal display device 1 includes two sheets of opposite substrates 2a and 2b using a glass substrate, plastic or film substrate. A color filter 9 or a switching active element 11 such as transistor array or a transparent electrode 8 are provided within both the substrates 2a and 2b, thus forming a device such as a passive method, TN-TFT or IPS. Further, a seal 5 is formed around the liquid crystal display device 1 and serves to seal filled liquid crystal 3. Furthermore, a manufacturing method of the liquid crystal display device 1 according to the present embodiment is a vacuum injection method. An inlet port is needed in the seal pattern 5. In FIG. 1, reference numeral 7 indicates an orientation film, and 10 indicates is a black matrix.

[0022]

In the liquid crystal display device 1, however, the gap between the opposite substrates 2a and 2b is formed by means of a gap control member. In this case, in order to form a gap of about 3 to 5 μm between the substrates 2a and 2b, a projection 6 is formed on one of the substrates. In the present embodiment, although the projection 6 is formed in the color filter substrate 2a, the projection 6 can be formed in any one of the substrates such as the array substrate 2b. Further, when forming the projection 6 on one of the substrates 2a and 2b using organic matter having a predetermined location or size, a ground area of the projection 6 and the substrate 2a becomes a square of 20 μm × 20 μm. If the pixel size is 90 μm × 270 μm, the projection 6 is formed in such a way that one projection 6 is disposed every three pixel arrangements having a pitch of 90 μm. The area density of the projection 6 becomes 0.54%. In this case, a location where the projection 6 is set is not a transmitting pixel. A location that is flat and does not have a step is appropriate on the black matrix (BM) 10 in the color filter substrate 2a, and on a gate wiring, capacitance and transistor in the array substrate 2b. Further, in this case, the compression elastic coefficient of the projection 6 is $150 \times 9.80665 \times 10^4$Pa(150kgf/$cm^2$) or higher.

[0023]

In this case, when the area density is less than 0.08%, the gap irregularity is generated, as shown in FIG. 2. This is because if the liquid crystal display device 1 is left along at a high temperature of 60℃ than room temperature since the ground area of the projection 6 is small, the liquid crystal 3 gathers at the bottom and generates gap irregularity. Furthermore, in this case, the elastic coefficient of the projection 6 is 150 kgf/cm^2 or higher.

[0024]

FIG. 3 shows a sealing process of making an optimal gap by pressurizing the liquid crystal display device 1. In FIG. 3, a longitudinal direction axis is a cell gap and a lateral direction is the time taken to pressurize the liquid crystal display device 1. In the construction of the present embodiment, when comparing the installation areas of 0.04% and 0.08%, a constant cell gap (e.g., 4.0 μm) can be obtained within a short time when the projection is 0.04%, compared to when the projection is 0.08%, as shown in FIG. 3. 0.08 μm or more time is taken until the liquid crystal is further compressed and reaches a stable region. As a result, the installation area of 0.08% can shorten the time until the cell gap is stabilized, compared to the installation area of 0.04%. As such, in a panel whose installation area is small, the center of the empty cell is swollen up. In the present embodiment, a uniform gap can be considered from the empty cell state. The time to compress the liquid crystal 3 can be significantly shortened due to the above effect.

[0025]

FIG. 4 shows a manufacturing flowchart showing according to an embodiment of the invention. As shown in FIG. 4, Substrates 2a and 2b are cleaned. After an orientation film of a liquid phase is coated by means of offset print, etc., the orientation film 7 is formed through a first sintering process and a second sintering process. An orientation process is implemented by rubbing, etc. Generally, after rubbing, in order to remove alien substance or dirty on the surface, water washing is performed. Further, in order to form a gap on one of the substrates 2a, a projection 6 having a predetermined size is provided at a predetermined place, or spacers 4 are evenly sprayed, as shown in FIG. 7. A condition in this case is that the area density of the projection 6 that forms the

gap or the spacers 4 is 0.08% or higher, the elastic coefficient thereof is 150kgf/cm^2, and organic matter forming the gap employs the projection 6 formed on the substrate or a spacer 4 having a spherical shape.

[0026]

A sealant 5 is coated on one of the substrates 2a by means of a patterning apparatus or screen printing, forming a seal 5. Further, when the top and bottom of both the substrates 2a and 2b are conductive, both the substrates 2a and 2b are connected using conductive ink. Several inlet ports are disposed in the seal pattern 5. The inlet port serves to inject the liquid crystal 3 through the aperture. The substrates 2a and 2b are then adhered in the atmosphere. In order to control the gap of the liquid crystal display device 1, the two sheets of the substrates 2a and 2b are pressurized by means of air press, etc. If an optimal gap is obtained, the sealant 5 is hardened. At this time, the thermosetting type sealant 5 is generally used.

[0027]

Thereafter, portions other than the substrate display region are cut to form an empty cell. The empty cell becomes a proper gap in the present embodiment although it is left in the atmospheric pressure. In the injection method, the aperture of the inlet port of the empty cell and the liquid crystal 3 are pooled and left in the vacuum tank. They are then closed about 0.2 to 0.7 Torr. The entire tank is open to the atmosphere and the empty cell is filled with the liquid crystal 3. The liquid crystal 3 filled in the cell of this state exceeds an optimal amount, and the gap also exceeds a proper size.

[0028]

Lastly, both sides of the liquid crystal display device 1 that is filled with the liquid crystal 3 are pressurized to have an optimal gap. The inlet port is tightly sealed with resin, etc. The liquid crystal 3 attached to the liquid crystal display device 1 is cleaned. A re-orientation process is performed on the liquid crystal 3 by annealing the entire liquid crystal display device 1.

[0029]

In the above process, the viscosity of the filled liquid crystal 3 is generally about 0.1 to 0.01Pas (or several tens of cP). If a temperature is applied to the liquid crystal 3, the viscosity lowers, but components having a volatile property may scatter. Thus, it is not preferred that a temperature is applied to the liquid crystal 3 in a common manufacturing process.

[0030]

In the present embodiment, in the method of compressing the liquid crystal 3 filled in the liquid crystal display device 1, both sides of the liquid crystal display device 1 are compressed so that they have an optimal amount, and the gap becomes proper. In the compressing method, one side or both sides of the liquid crystal display device 1 is compressed using silicon rubber such as balloon, or both sides of the liquid crystal display device 1 are pressed against the base plate using air press.

[0031]

As shown in FIG. 5, if the filled liquid crystal display device 1 is pressed at a pressure of $2\times9.80665\times10^4$Pa(2kgf/cm^2) or higher, the projection 6 that is formed under the condition in which the area density is 0.08% or higher and the elastic coefficient thereof is 150 kgf/cm^2 or higher collapse, or the spacers 4 are broken or the color filter 2a sinks. Accordingly, in the present embodiment, it is

necessary to press the liquid crystal display device 1 that is filled at a pressure lower than $2kgf/cm^2$ up to to a specific gap.

[0032]

As described above, in the present embodiment, the empty cell of the liquid crystal display device 1 consisting of two or more sheets of the substrates 2a and 2b in which the liquid crystal 3 is filled in the vacuum tank, the area density of organic matter or inorganic matter that forms two or more sheets of the substrates 2a and 2b of the liquid crystal display device 1 is 0.08% or higher, and the elastic coefficient thereof is 150 kgf/cm^2. The organic matter forming the gap is the projection 6 formed on the substrate 2a or the spacer (ball) 4 having a spherical shape. Thus, in the sealing process of pressurizing the already filled liquid crystal display device 1 to make an optical gap, the time of compressing the liquid crystal 3 can be significantly shortened.

[0033]

Furthermore, the liquid crystal display apparatus can be fabricated by the manufacturing apparatus of the liquid crystal display apparatus that allows the manufacturing method to be performed.

[0034]

[Effects of the Invention]

In accordance with the liquid crystal display apparatus of Claim 1 according to the present invention, the area density of a gap control member that forms a gap of the opposite substrates of the liquid crystal display device is 0.08 % or higher, and the compression elastic coefficient thereof is $150 \times 9.80665 \times 10^4 Pa (150 kgf/cm^2)$ or higher. Accordingly, upon manufacturing of the liquid crystal display apparatus, the time taken to compress the liquid crystal

from when an empty cell is filled the liquid crystal until when a proper gap is compressed can be shortened. More particularly, as lead time shortens, not only a low-cost liquid crystal panel cane be provided, but also the gap uniformity within the panel surface is excellent in terms of the quality. Further, vibration within the panel surface due to vibration of a complete panel can be improved.

[0035]

In Claim 2, since the gap control member forming the gap of the opposite substrates of the liquid crystal display device is a projection formed on a substrate, it can be previously provided in a predetermined location of the substrate upon fabrication.

[0036]

In Claim 3, since the gap control member forming the gap of the opposite substrates of the liquid crystal display device is a ball having a spherical shape, it can be uniformly sprayed on the substrate upon fabrication.

[0037]

In accordance with a manufacturing method of a liquid crystal display apparatus of Claim 4 according to the present invention, in a state where the area density of a gap control member that forms a gap between the opposite substrates of a liquid crystal display device is 0.08 % or higher, and the compression elastic coefficient thereof is $150 \times 9.80665 \times 10^4$Pa($150$kgf/cm^2) or higher, the substrates are adhered to form an empty cell of the liquid crystal display device, and injecting liquid crystal from an inlet port of the empty cell into a vacuum tank, and the liquid crystal is compressed from the inlet port by applying pressure of $2 \times 9.80665 \times 10^4$Pa($2$kgf/cm^2) or less to a given gap. The time from when an empty cell is filled with liquid crystal until when the liquid crystal is

compressed up to a proper gap can be shortened. Thereby, process tact for filling the liquid crystal of the liquid crystal display device can be significantly shortened. Further, a liquid crystal display apparatus with a high yield can be fabricated simply and by means of a conventional manufacturing method. More particularly, a low-cost the liquid crystal panel can be provided through reduction in lead time. Meanwhile, in terms of the quality, the gap uniformity within the panel surface is good, and vibration within the panel surface due to vibration of a complete panel is improved.

[0038]

In the future, it is apparent the inch size of the liquid crystal panel is large-sized. Although the length of the time taken to compress liquid crystal becomes problematic, and the gap uniformity becomes more difficult, the lead time can be reduced and high quality can be obtained by the manufacturing method of the present invention.

[0039]

In Claim 5, since the gap control member forming the gap of the opposite substrates of the liquid crystal display device is a projection formed on a substrate, it can be provided at a predetermined location of the substrate.

[0040]

In Claim 6, since the gap control member forming the gap of the opposite substrates of the liquid crystal display device is a ball having a spherical shape, it can be evenly sprayed on the substrate.

[0041]

In accordance with a manufacturing apparatus of a liquid crystal display apparatus according to Claim 7 of the present invention, since the manufacturing

method according to any one of Claims 4 to 6 is implemented, the same effects can be obtained.

[Description of Drawings]

FIG. 1 is a cross-sectional view of a liquid crystal display apparatus according to an embodiment of the invention.

FIG. 2 shows the relation between the area density and the gap irregularity according to an embodiment of the invention.

FIG. 3 shows the relation between the cell gap and a pressurization time according to an embodiment of the invention.

FIG. 4 shows a manufacturing flowchart showing according to an embodiment of the invention.

FIG. 5 shows the relation between pressurization and the gap irregularity according to an embodiment of the invention.

FIG. 6 shows a manufacturing flowchart of a conventional example.

FIG. 7 is a cross-sectional view of a liquid crystal display apparatus according to a conventional example.

[Explanation on Numerals]

1: Liquid crystal display device

2a, 2b: Substrate

3: Liquid crystal

4: Spacer

5: Seal

6: Projection

7: Orientation film

8: Transparent electrode

9: Color filter

10: Black matrix

11: Switching active element